Report for 2002DE1B: Graduate Fellowship in Water Quality: The Role of Land Use and Land Cover in the Delivery of Nutrients to Delaware's Inland Bays

- Water Resources Research Institute Reports:
  - Jennings, Jennifer, William Ullman, and Joseph Scudlark. March and June 2002. The Role of Land Use and Land Cover in the Delivery of Nutrients to Delaware's Inland Bays. Annual reports to the Delaware Water Resources Center, University of Delaware, Newark, Delaware, 12 and 3 pages, respectively.
- Other Publications:
  - Jennings, Jennifer. 2003. The Role of Land Use and Land Cover in the Delivery of Nutrients to Delaware's Inland Bays. M.S. Thesis, University of Delaware, Newark, Delaware. 163 pages.

Report Follows:

Delaware Water Resources Center Research Program: Fellows

The following three research projects are DWRC-funded graduate fellowships granted in December 1999 and spanning a three-year period. Related presentations are found in the Information Transfer section. A final report to the DWRC for each of the three fellowships is expected by August, 2003.

Basic Information: Fellow Project #1 (of 3)

Title:	The Role of Land Use and Land Cover in the Delivery of Nutrients to Delaware's Inland Bays
NIWR Project Number:	**2002DE1B**
Start Date:	3/1/2000
End Date:	2/28/2003
Funding Source:	104B
Research Category:	Water Quality
Focus Category:	Water Quality(WQL), Models (MOD), Nutrients (NU), Non Point Pollution (NPP)
Descriptors:	Eutrophication, Land Use, Nitrogen, Nutrients, Rainfall-Runoff Models, Rainfall-Runoff Processes, Water Quality, Water Quality Monitoring
Principal Investigators:	Jennifer Jennings, University of Delaware M.S. candidate
Other Principal Investigators:	William Ullman ullman@udel.edu, and Joseph Scudlark scudlark@udel.edu, College of Marine Studies, University of Delaware, advisors.
Project Class:	Research

Previous Project Numbers: DWRC G-03 (FY00); NIWR 2000DE3G (FY00) and 2001DE3681B (FY01)

Publication

1. Jennings, Jennifer, William Ullman, and Joseph Scudlark. March and June 2002. The Role of Land Use and Land Cover in the Delivery of Nutrients to Delaware's Inland Bays. Annual reports to the Delaware Water Resources Center, University of Delaware, Newark, Delaware, 12 and 3 pages, respectively.

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Names and degree level (highest level during the reporting period) of all students who worked on the research project: Jennifer A. Jennings, M.S. recipient April, 2003.

A DWRC newsletter article on this project may be found at: http://ag.udel.edu/dwrc/newsletters/JenningsSpr2002.pdf

Abstract (of M.S. thesis based on this fellowship's research)

In this research, the discharge of water and associated nutrients from one sub-watershed of Delaware's Inland Bays (Bundicks Branch) was studied in detail so that total nitrogen and phosphorus loads from this tributary, and potentially others with similar geological, hydrological, and land use characteristics could be determined. The calculated loads, based on measured data were compared to previous model estimates, which have been and continue to be used by managers, for the establishment of nutrient loading targets and land use management practices within the watershed.

In order to accurately determine storm loads at Bundicks Branch, an alternative baseflow minimization separation technique, which reduced and ultimately shut off groundwater inputs under the peaks of storm events, was developed. This model yields more reliable estimates of baseflow and storm loads at this tributary. Samples collected during both the hourly and daily sampling experiments revealed that dissolved nutrient concentrations fluctuated little (<12%) within a day and between sampling dates, while particulate constituents were more variable on both time scales and calculated loads can carry a greater degree of uncertainty (>40%).

Storm loads of 17 monitored events at Bundicks Branch were evaluated for seasonal trends and used to project annual storm loads. Normalization of storm loads by precipitation amount (P) and integrated storm discharge (Q) revealed that the loads per unit P or Q of sequential monitored events were fairly similar. The loads of unsampled storms between monitored events were therefore determined using the average "per unit" loads of the previous and following sampled storms.

These same, and similar, flow based calculations were applied to less studied sub-watersheds. As a result of the detailed study conducted at Bundicks Branch, annual nutrient loads in both the baseflow and stormflow discharge components could be estimated at two similar sites using the Bundicks Branch model calibrated with data from these sites. Using this approach, total, baseflow, and storm loads may be determined with substantially less discharge and water quality data.

The loads computed in previous chapters using flow-based calculations were used to evaluate loading estimates produced by land use-based nitrogen and phosphorus models. The estimated loads from the Ritter (1986a), Horsley & Witten (1998), and USDA (Cassell and Meals, 1999) models appear to represent an upper bound to the actual nutrient loadings. The Ritter (1986a) approach gave very good estimates of N when applied to Bundicks, while the Horsley & Witten (1998) approach produced a value approximately 30% greater then the measured loads. Both the Ritter (1986a) and USDA (Cassell and Meals, 1999) P models overestimated measured P loads at Bundicks Branch by 400%. These results indicate that existing non-point discharge targets should be revised in light of recent observations.

It was also determined, after analysis of atmospheric N and P deposition rates to the watershed, that the land uses of Bundicks Branch attenuated both N and P on a seasonal basis with peaks in attenuation occurring during the peak-growing season. Thus, the land uses and land covers of the studied sub-watersheds were found to take on both the role of net nutrient source and the role of net nutrient sink at different times of the year. Future management practices that take into account the seasonality of nutrient attenuation in the watershed, may better achieve management goals.

Finally, the nutrient loadings determined at Bundicks Branch during this study were extrapolated to represent the non-point source load from the entire Rehoboth Bay sub-basin and were compared to the loading contributions from direct atmospheric deposition and the Rehoboth Wastewater Treatment Plant. This analysis revealed that prior nitrogen budgets were sound, with the watershed contributing close to 80% of the annual N load to the bay, 17% from direct atmospheric deposition, and 4% from the WTP, but suggested that the actual phosphorus budget is substantially different then previously believed. On an annual average basis, this approach estimates that the watershed and Rehoboth WTP contribute relatively equal proportions of the P load to Rehoboth Bay at 41 and 45% respectively. In addition, it appears that the loading proportion from the WTP can be even greater during summer months, especially those that are dry, suggesting that focus should also be paid to the management of point sources in regard to nutrient pollution.